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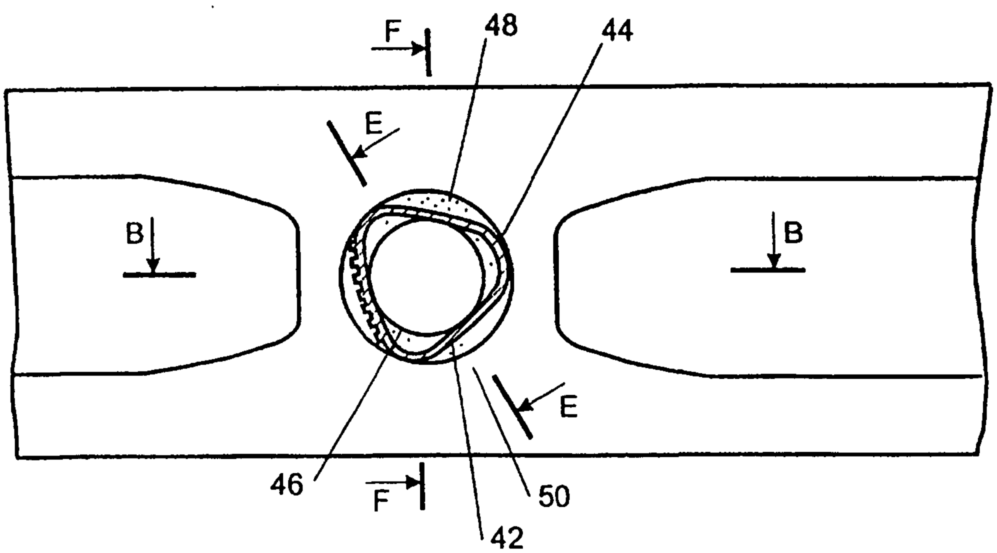

(57) Abstract

A structural support assembly, more particularly incorporating a joint useful in the preparation of structural support assemblies such as ladders, scaffolds and trusses. The joint has a male member (42) with an open–ended hollow projection which defines an inner wall and an outer wall. The joint also has a wooden female member having a socket defined by a groove in the form of a closed loop having opposing walls. The projection of the male member is fitted in a clearance fit in the socket and is secured therein by a binding material which contacts the inner and outer walls of the projection and the opposing walls of the socket. The binding material also permeates the female member surrounding the socket. A process for the preparation of such structural supports is also described.

STRUCTURAL SUPPORT ASSEMBLY

Technical Field

The present invention relates to a structural support assembly, more particularly to a structural support assembly incorporating a joint and to processes for making same. Typical structural support assemblies are ladders, scaffolds and trusses.

Background Art

In this specification, "wooden" refers to the property of having wood or wood fibres. Accordingly, timber, chipboard, high density chipboard and wood fibres encased in a polymeric matrix are all encompassed by this definition.

In this specification, a "clearance fit" refers to the property of having space between two connectable portions of two members for a major portion of the surface area of the portions, preferably between 70% and 100% of the surface area of the two portions, more preferably 90% to 100% of the surface area of the two portions, most preferably in excess of 95% of the surface area of the two portions.

Wooden structural supports are useful, for example, in the construction and maintenance trades for performing work that, *inter alia*, requires that persons be electrically insulated whilst on the structures. An example of this type of work is high voltage conductor repair and installation. Examples of the wooden structural supports contemplated are ladders, scaffolds, trusses and any other supports containing wooden members that involve wooden/wooden, wooden/metal, and wooden/plastics joints.

However, wooden structural supports suffer from the disadvantage that they can break. Such breakages are often caused by fractures or weak points in the wooden member at or near the joints. In the case of ladders with wooden stiles, these fractures are at or near the joint between the stiles and the rungs.

One of the important features of a good support is the rigidity of the joint or joints it comprises. Accordingly, wooden structural supports can also suffer from the disadvantage that the wooden member adjacent a joint is sufficiently deformable to cause the joint to become flexible, eventually leading to fracturing, play in the joint or separation of the members. If the companion member to a wooden member is hollow at the joint, such as a hollow rung on a ladder, this can also deform to allow flexibility of the joint. It will be appreciated that even having play in a joint can mean that the support becomes dangerous to use.

In many instances, structural supports have the further requirement that they must resist both translational and rotational forces applied to the joints. For example, ladders must resist racking, twisting and sideways forces as applied to the ladder as a whole. Ladders must also resist rotational forces applied to rungs, particularly where the rungs are of the 'D' section type where the orientation of the stepping surface of the rung with respect to the stile is important.

A number of inventors have grappled with the problem of providing more robust wooden joints. For example, US 5,466,086 (Goto) teaches that wooden pieces in a clearance fit arrangement may be joined together by a viscous liquid adhesive. However, Goto goes on to teach that absorption into the wooden pieces forming the joint is undesirable. For example, at column 9, lines 2 to 6, it is stated, "this work is carried out to prevent the adhesive agent from being absorbed, be lacking in amount, and having its adhering force, reduced in response to the type of wooden material (laminated wood) or concrete." Goto joints therefore are designed to prevent invasion of adhesive into the wood surrounding the joint. The present inventor has found that joints of the type described by Goto suffer

from the disadvantage that, although the glued joint itself may be relatively strong, the weak portion in such joints is often close to the glued surfaces in the wood itself. Such joints tend to weaken and fracture in the wood immediately proximal the joint.

US 5,037,234 (De Jong) also teaches the use of a clearance fit arrangement in the joining of wood pieces by means of dowels. The advantage of the De Jong joint at column 3, lines 19 to 26 is stated as, "In contrast to the state of the art, the type of glue used here according to the invention is of a type which after curing stays permanently tough elastic, so that some movement (expansion) between the members 1, 2 is allowed, without running the danger that the connection will be broken due to over-loading the layer of glue, or due to breaking of the adjacent wood, as is a well known phenomenon." De Jong therefore highlights the problem of the wood fracturing proximal the joint. The solution posed by De Jong is a permanently elastic glue layer interposed between the wooden pieces to absorb some of the stresses imposed on the joint. However, such joints may lose their elasticity over time. More importantly, in the case of structural supports, any play in the joint could have potentially negative effects on structural stability. In structural supports, it is important to have a rigid joint without play. For this reason, many of the Standards for structural supports call for a substantially rigid joint.

US 4,925,331 (Bertsche) also provides a solution for connecting wooden members. This is achieved by the insertion of a power transmitting bar into a blind bore in a wooden member, inserting retaining dowels perpendicularly to the power transmitting bar and a rigid casting compound which fills the space between the sides of the blind bore and the power transmitting bar to form a composite block. The Bertsche joint is complex in manufacture, requiring a number of components and steps in its construction. Owing to its complexity, it is also difficult to implement as a consequence of the number of components involved in joint members where space is at a premium. The Bertsche joint may

therefore be problematic in joints for ladders, stiles and trusses. Finally, Bertsche is silent as to how to prevent breakage that often occurs in the wood around a joint rather than in the joint itself.

Often the problem that exists with joints in the prior art is that there is insufficient supporting material around the joint to give adequate strength to the joint.

Another problem that occurs in joints that involve hollow wooden members where a substantial amount of binding material has to be introduced into the joint area is that adhesive has to be introduced into a wooden member with a blind hole. If a liquid uncured binding material is used, an airlock can form in the hollow member displacing the binding material, preventing invasion of the glue into the inner surface of the hollow member and causing spillage of binding material out of the joint. This can be minimised by use of a viscous binding agent, which is less deformed by airlock pressure. However, such joints suffer from the disadvantage that they fracture in the wood adjacent the joint.

A potential solution to the airlock problem is to drill a hole into the hollow member to equalise the pressure between the inside and the outside of the member, thereby preventing an airlock. However, such an approach is often undesirable. A number of Standards exist for the construction of ladders and stiles. An example of such a Standard is AS/NZS 1892 1996. This Standard requires in part 1 clause 2.5.2.b, part 3 clause 2.6.2.b and in the draft of part 4 clause 2.5.2.b that "Where stiles are manufactured from hollow section material, means shall be provided to prevent the retention of water within the stile." Additionally, holes not within the joint may act as starting points for future failure of the structural member.

A hole could be drilled in a non structural part of a ladder stile to permit the free flow of air, which hole could be plugged after curing of the binding material.

However, this has the disadvantage that it introduces an extra step into the process of joint construction. The finish of the completed article may also be negatively impacted by the presence of such drilled and filled holes.

Accordingly, a joint which is stronger than those known in the art or which at least provides the public with a useful choice would be a useful contribution to the art.

Disclosure of the Invention

Accordingly, in a first aspect, the present invention provides a structural support assembly comprising at least a male member in engagement with a settable binding material in engagement with a wooden female member, wherein:

the male member has an open-ended hollow projection, the projection defining an inner wall and an outer wall;

the female member has a socket defined therein by a groove in the form of a closed loop having opposing walls, the groove being shaped to receive said projection of the male member such that the projection of the male member forms a clearance fit with the socket of the female member;

the binding material contacts opposing walls of the socket of the female member and the inner and outer walls of the projection of the male member; and

said binding material has permeated and strengthened the wooden female member adjacent the socket.

A further aspect of the invention provides a support structure comprising at least a first and a second structural support assembly as defined in accordance with the first aspect, wherein one of the members of the first assembly is a member of the second support assembly.

A yet further aspect of the present invention provides a process for manufacturing a structural support assembly comprising the steps of :

providing a wooden female member with a socket defined therein by a groove in the form of a closed loop having opposing walls;

providing a male member having an open-ended hollow projection which defines an inner wall and an outer wall such that it forms a clearance fit with the socket of the female member;

inserting the male member projection into the female member socket;

either before or after this insertion of the male member projection into the female member socket, introducing a binding material into at least the socket wherein the binding material is permitted to permeate the wooden female member adjacent the socket and contact at least the opposing walls of the socket and when the male member projection is inserted into the female member socket, the inner and outer walls of the projection of the male member;

retaining the male member in a predetermined relationship with the female member; and

hardening the binding material.

The invention extends to ladders, scaffolds and trusses containing at least one joint of the invention.

With reference to the first aspect of the invention, it is preferred for the settable binding material, in its unset state, to have a fraction with a viscosity of between 200 and 1000 centipoise. It is also preferred for the fraction to comprise at least 5% by weight of the total binding material.

It is preferred for the binding material to contact a major proportion of the opposing walls of the socket of the female member, more preferably 80%. It is also preferred for the binding material to contact a major portion of the portion of the inner and outer walls of the projection of the male member within the confines of the socket, more preferably 80%.

It is preferred that at least one of the members is elongate, more preferably, that both members are elongate.

The projection may be an end of the male member. The projection may alternatively protrude from a portion along the length of the male member.

The socket may be defined by an end of the female member. The socket may alternatively be defined in a portion along the length of the female member.

It is preferred that the structural support assembly be incorporated into a construction selected from a ladder, stepladder, scaffold and truss. Either member may be a stile. Where one of the members is a stile, the other member may be a rung. Multiple structural support assemblies may be employed in a single construction. It will be appreciated that the construction may have multiple rungs and multiple stiles. Each stile may have multiple attachments for rungs. Conventionally, rungs also have two ends for attachment to two stiles. In a preferred embodiment, the male member is a rung and the female member is a stile.

The male member, such as in ladders, may be provided with other portions, such as clamps and hooks. In such cases, the projection that is received into the socket may not necessarily be the end of the male member. However, any projection that is capable of being received into the socket will suffice for the purposes of the invention.

A support structure preferably comprises a plurality of structural support assemblies. It is particularly preferred that a support structure comprises two female members and a plurality of male members. Alternatively, a support structure may comprise two male members and a plurality of female members.

Both male and female members may be wooden. Where both members are wooden, one member is preferably of a stronger wooden material than the other member.

The male and female members may be made of any practicable material having strength, stiffness, ductility and durability. Suitable materials for the male member include metals, preferably aluminium, wood, FRP (fibre reinforced plastics) and plastics. FRP may also include plastics reinforced with wood fibres. It is preferred that the members be weatherproof.

The binding material should be chosen to be sufficiently strong so as not to break when loaded or stressed by the usual loads placed upon the joint in use. The binding material may be a polymer, preferably a resin. The resin may be any durable, hard, strong, settable resin including, but not limited to, one selected from the group comprising epoxy, polyester, polyurethane, and acrylic.

It is generally important for the cured binding material to have a high solids content in the form of high molecular weight components to ensure rigidity. The extensive use of solvents in binding material should therefore be minimised to prevent cracking of the binding material due to shrinkage caused during the

setting process. It is therefore preferred that the binding material be substantially non-shrinking during curing. This also prevents the binding material from pulling away from the members during curing. Accordingly, epoxy-based resins and reactive hot-melt resins are most preferred. Hot-melt resins include isocyanate-based and polyurethane-based resins, either alone or in combination.

In order to permeate the wood adjacent the socket, it is preferable for the binding material be chemically curable. The uncured binding material should have a fraction component of at least 5% of the binding material by weight which has a viscosity of between 200 and 1000 centipoise in order to permit the resin to permeate the wood adjacent the socket prior to curing . Preferably, the fraction component should be at least 10%, more preferably at least 20%. It is preferred for the overall viscosity of the binding material to be between 200 and 10,000 centipoise, more preferably between 2000 and 7000 centipoise, most preferably between 4000 and 6000 centipoise in order to achieve a high solids content and a low viscosity component fraction.

It is also preferred that the binding material adheres to the wooden member. It is particularly preferred that the binding material adheres to both male and female members. In one embodiment, the binding material is an acrylic resin which is two part settable and which binds to wooden articles and to aluminium. The resin may also be reinforced by addition of glass fibres or other reinforcing materials.

In another embodiment, the male member is a 'D' section rung, alternatively an 'O' section rung. The male member is hollow proximal at least one end. It is particularly preferred for the male member to be tubular. The rung may have grooves extending longitudinally across its surface to improve the grip of the rung in use. Where the rung is a 'D' section rung, it is preferable for grooves to extend on the flattened surface of the 'D' alone. Also in the case of the 'D' sectioned rung, it is preferred for the flattened surface to be at an angle of

between 90 degrees and 65 degrees to the longitudinal axis of the stile, more preferably 75 degrees.

It is preferred that the socket be an annular groove. As will be appreciated, the male member projection must necessarily be hollow in order to seat in the socket. The groove can be of any practicable shape. In this specification, in a closed loop groove, the walls nearer the enclosed portion of the loop are called inner walls, whereas the opposing walls are called outer walls. It is particularly preferred that the socket be a trepanned annular groove, in which case the opposing walls of the groove define an inner and an outer wall of the socket.

It is preferred that the projection of the male member be of a different shape from the socket in cross section such that it contacts both the inner and outer walls of the socket at different portions in cross section, more preferably, that the projection be a smoothed polygon. It is most preferred that the smoothed polygon has three sides and therefore be generally triangular in shape, thereby matching the shape of the rest of the preferred and so-called D-sectioned rung.

In one embodiment, the male member has protrusions which contact at least one of the walls of the socket, preferably the inner wall(s).

In another embodiment, the projection on the male member is deformed so as to have a different profile in cross section along its length proximal an end. The purpose of this is to enable the male projection to be anchored in the binding material when set.

In yet a further embodiment, the projection of the male member has at least one hole which is filled with binding material.

In the process for manufacture aspect, it is preferred for the settable binding material, in its unset state, to have a fraction with a viscosity of between 200 and 1000 centipoise. It is also preferred for the fraction to comprise at least 5% by weight of the total binding material.

It is preferred for the binding material to contact a major proportion of the opposing walls of the socket of the female member, more preferably 80%. It is also preferred for the binding material to contact a major portion of the portion of the inner and outer walls of the projection of the male member within the confines of the socket, more preferably 80%.

The process may additionally comprise forming a projection on the male member.

Where the binding material ultimately comprises a cured polymer, the precursor monomer and a curing agent may be pre-mixed. The binding material may be applied to the projection, the socket or both. In one embodiment, the precursor monomer and curing agent may be separately applied to the socket and projection and mixed by the joining of the two members. However, premixing the monomer and curing agent is more preferred.

The process may additionally comprise retaining the members in a jig until the binding material has hardened.

The process may additionally comprise forming at least one hole in the male member projection. It is preferred that the at least one hole be drilled. It is also preferred that the at least one hole be filled with binding material when inserted into the socket. Without wishing to be bound by theory, it is believed that such holes are advantageous as they are ultimately covered in binding material, which may permeate through the hole and assist in binding the male member to the

female member. The hole is also not a water trap or a weakening point in the male member as it is ultimately filled with binding material.

A preferred process of manufacture is as follows: the female member is manufactured and finished with a finish, if required. The finish chosen may be a varnish or a paint. The female member should preferably not be oiled as this may inhibit the permeability of the wood by the binding material and/or prevent the bonding of the binding material to the female member. A socket is formed in the female member. In one embodiment the socket is formed by trepanning an annular groove into the female member. By this method the socket walls comprise unfinished material. Further socket may be formed in the same female member, as required. Unfinished socket walls tend to be more permeable to binding material than finished socket walls.

The male member may then be prepared if not pre-prepared beforehand. Where the male member is wooden, the ends should be bare wood which will soak up resin. Where the male member is a metal, the ends should preferably be deformed and/or drilled to provide mechanical attachment to the binding material. Where the male member is FRP (fibre reinforced plastics), the ends should be abraded to remove any surface resins, waxes or paints and may optionally be drilled to form holes therein.

The female member may be placed on a substantially horizontal level surface with the socket facing upwardly. The projection of the male member is placed in the socket. Optionally, the male member may be oriented with respect to the female member, if required. For example, in the case of a ladder with a tubular "D" section rung, the flat surface of the rung is preferably rotated to an angle of 75° from the longitudinal axis of the stile. The flat surface should preferably be a non-slip surface.

The male and female members may be placed in a retaining device, preferably a jig, in order to retain the male member at the desired rotation angle and orientation with respect to the female member. Alternatively, a jig retaining just the male members may be employed.

It will be appreciated that multiple male members may be inserted into multiple sockets in a female member. This is preferably done sequentially as per the above whereby each step is repeated for each joint to be completed and only advancing to the next step once all of the members have been subjected to said step. Where multiple male members are employed, the retaining device may be utilised to retain all of said members. Such a multiple male member retaining jig may, in addition to the previously mentioned functions, be utilised to separate the male members from one another at set distances apart.

Where the binding material comprises a two part resin mixture, the measured parts may now be mixed. The volume of unset binding material introduced into the socket may be pre-measured. Where the male member is tubular, a volume of unset binding material is preferably loaded into an open top end of each male member.

In one embodiment, it is preferred to ensure that the unset binding material is actually poured to run down the inside faces of the male member and not to immediately form a plug which would form an undesirable airlock within the male member when the base of the plug is above the level of the socket. The unset binding material running down the inside faces of the male member fills the socket.

Soakage into the wood adjacent the socket is made up for by the rest of the resin running down off the side walls so that, after a short time, typically less than 10 minutes, the top of the resultant plug of resin reaches and remains flush with the upper surface of the female member. Another method for ensuring that the resin

fills the socket to the required extent is to refill the socket with unset binding material at least once more to the desired level after time has been allowed for soakage into the wood to occur.

Alternatively, and particularly where the male member is not tubular, the unset binding material may be loaded directly into socket and allowed to soak into the wood. The male member may be pre-treated with unset binding material at the end to be placed into socket to ensure a good resin coverage.

In order to control the invasion of unset binding material in the socket and into the wood, the temperature may be controlled. Typically, this is by way of placing the structural assembly into a temperature controlled environment. Higher temperatures tend to make unset binding material less viscous until set, but decrease the setting time. Lower temperatures generally increase the viscosity of the unset binding material but increase the setting time. Thus, by altering the temperature, the degree of invasion into the wood by the unset binding material can be altered.

Another factor that can influence the invasion of unset binding material into the wood is pressure. An hermetically sealed chamber for housing the structural support assembly may therefore be provided with a pressure altering device, preferably a pump for increasing pressure and reducing pressure within the chamber. A pressure measuring device may also be provided for determining the pressure within the chamber.

More importantly, however, is the effect of a pressure differential. Such pressure differentials may be created locally within the joint where one of the members is tubular. A male tubular member may be sealed on one end, effectively sealing in a volume of gas within the member when a volume of unset binding material seals the other open end.

Unset binding material in the male member can be made to act as a separation barrier between gas trapped inside the member and ambient gas surrounding the support assembly. By increasing the temperature inside the member, the pressure of the gas inside the member also increases. In such a case, a decrease in the pressure surrounding the member, or an increase in pressure within the member causes a net force to be exerted on the unset binding material thus driving it out of the member. Alternatively, the pressure inside the member may be decreased or the ambient gas pressure surrounding the support assembly may be increased, thereby exerting a net force on the unset binding material driving it into the member.

Pressure within the member may be increased and decreased by increasing and decreasing the temperature, respectively. Accordingly, means to adjust the temperature locally within the member may be provided by, for example, applying a heating element to the member. External ambient pressure may be adjusted by altering the pressure within the hermetically sealed chamber.

Other means to provide a localised pressure change are contemplated. One way of achieving this is to attach a pumping device to the free end of the tubular member.

By providing a pressure differential, the amount of force exerted on the unset binding material is alterable. The amount of pressure force chosen to be exerted on the unset binding material depends upon a number of factors, including the viscosity of the unset binding material, the setting time of the binding material, and the permeability of the wooden material in the female member.

A further effect that can be produced from the pressure differential is contemplated where an increase in pressure can be used to drive the binding material into the wooden female member. By increasing the pressure within the hollow member, the unset binding material is forced into the wooden member.

The amount of pressure to exert on the binding material depends upon the nature of the binding material and the nature of the wood, including permeability. If the wood has a considerable number of large resin tracks, a large increase of pressure may be undesirable as this drives the resin a considerable distance through the tracks while limiting localised wood permeation of the binding material. Typically, a useful pressure increase on the inside of the tubular member is of the order of about 0.25 psi (about 1700 Pa) for medium density woods.

The joint assembly may be held until the unset binding material has set sufficiently to be safely moved without disturbing the joint.

Basic cure times for setting the binding material vary widely depending on the nature of the binding material used. For most epoxy-based adhesives, this time is generally of the order of between 60 minutes and 500 minutes. Basic curing times may be utilised, provided the binding material is sufficiently set, to enable handling of the structural support after basic curing. Full cure may take up to one week.

In the case where the male member is to be used for a second assembly (such as in ladder construction), the free end of the male member may be treated with a volume of liquid resin. Where the male member is hollow, a volume of resin may be loaded into the open end of the member. A socket of a second female member may be placed over the open end of the male member.

The entire assembly may then be turned such that the second female assembly is now face up. Where no or insufficient resin has been loaded into the member, more resin may be loaded into the second female socket. The assembly may now be retained in a jig. The whole assembly should be so retained until the resin has set sufficiently for removal without disturbing the second joint.

Finally, the joint assembly or joint assemblies should be kept in storage, ensuring it/they remain straight, square and free of twist, until resin has cured sufficiently for use. This is typically more than 24 hours.

In the case of wooden or solid male members, the procedure most preferred is similar to that above. However, the resin may be poured into the socket in the upwards-facing female member and the male member lowered into the resin pool so formed while the male member is held in said jig. The jig may be set up to lower the male member into the socket at a predetermined rate to ensure that the rate of volume of male member inserted into the socket is of a similar order to the rate of volume of resin permeating the wood. It is preferred that the male member be lowered into the socket such that the male member's bottom surface abuts the lower surface of the socket.

Without wishing to be bound by theory, the inventor believes the strength of the joint disclosed herein is imparted because it provides an increased surface area of contact of binding material with the surrounding wooden female member and provides a gradient of binding material, binding material and wood and wood, instead of the usual binding material and wood junction of conventional joints.

Brief description of the drawings

The invention will be described below with reference to the accompanying drawings. The exemplifications are provided by way of example only and are not intended to limit the invention.

Figure 1A is a plan view of a grooved socket in a female member of the invention, for example, a stile of a ladder.

Figure 1B is a transverse sectional side view through a socket of a female member through B-B, as shown in Figure 1A;

Figure 2 is a plan view of a joint according to the invention with a D section rung with projections in a socket of a female member.

Figure 3 is a side view of a male member with holes according to the invention in a cut-away section of a socket and surrounding wood.

Figure 4A is a plan view of a joint of a ladder according to the invention.

Figure 4B is a sectional side view through B-B as depicted in Figure 4A.

Figure 4C is a sectional view through C-C as depicted in Figure 4B.

Figure 4D is a sectional view through D-D as depicted in Figure 4B.

Figure 4E is a sectional side view through E-E as depicted in Figure 4A.

Figure 4F is a sectional side view through F-F as depicted in Figure 4A.

Figure 5A is a perspective view of a rung useful in the invention.

Figure 5B is a further perspective view of the rung shown in Figure 5A.

Figure 6 is a set of standard layout composite views of the rung depicted in figures 5A and 5B.

Figure 7A is a partial plan view of a stile useful in the invention.

Figure 7B is a sectional side view through B-B as depicted in figure 7A.

Figure 8 is a schematic representation of a curing box useful in the invention.

Figure 9 is a partial sectional side view through a stile, rung and jig stile assembly.

Figure 10 is a partial plan view of a jig stile useful in the processes of the invention.

Figure 11 is a partial side view of a stile, rung and jig stile assembly.

Detailed description of the preferred embodiments

The invention will now be described further with reference to the figures.

With reference to Figures 1A and 1B, a female member, in the form of a ladder stile is depicted and generally indicated as (10). The stile comprises an elongate wooden body (12) with a trepanned annular socket (14) therein. The socket (14) has inner (16) and outer (18) walls defined therein.

With reference to Figure 2, a male member, in the form of a rung (20) for a ladder is depicted. The rung comprises inner (22) and outer (24) surfaces. A non-slip top surface (26) to the rung is provided on the outer surface (24) and inwardly directed protrusions (28) extend from the inner surface (22) of the rung. The rung (20) is generally triangular with rounded corners (30, 32 and 34) in cross section. When inserted into the female member depicted in Figures 1A and 1B, the outer surface (24) of at least one of the corners (30, 32 or 34) engages against the outer walls (18, Figure 1) of the socket. The inwardly directed protrusions (28) alone engage against the inner wall (16, Figure 1), typically in an interference fit engagement. The non-slip surface of the rung (26) may also engage against the outer wall (18, Figure 1). The rung can be provided without inwardly directed protrusions as shown in Figures 5A, 5B and 6, discussed more fully below.

Figure 3 depicts an end of a hollow rung (36) wherein holes (38 and 40) have been formed in the rung below the depth of insertion into a socket. In use, the rung is inserted into a socket and binding material at least partially fills the holes.

With reference to figures 4A to 4D, an aluminium rung (42) is shown inserted into a trepanned annular groove socket (44) in a wooden stile (46). Binding material in the form of resin (48) fills the socket and permeates into the wood surrounding the socket (50). The resin used by the inventor is obtainable from Protective Paints Limited, PO Box 58152, Greenmount, Auckland, New Zealand. The epoxy resin and hardener from this source are mixed together in a ratio of 4:1. A pumping machine which mixes the correct proportions of resin and hardener and delivers the mixture may be used. The rung is deformed as depicted in figures 4B to 4F from a rounded triangular cross section proximal the top of the socket (50) (Figure 4C) to a substantially round cross section (Figure 4D) at the base of the socket (50). The deforming of the rung (42) prevents

withdrawal from the socket (44) by means of being trapped in the resin (48) around the deformed portions thereof.

Although the above description is related to ladders, it will be appreciated that a joint with the rigidity taught herein will be applicable to other structural support assemblies used in industry. Examples where such support assemblies are useful include trusses, scaffolds and stiles.

The most preferred process for manufacturing a ladder will now be discussed:

With reference to the perspective views depicted in Figures 5A and 5B, an extruded 'D' section hollow aluminium ladder rung (52) with longitudinal gripping grooves (54) is depicted. The rung is pressed to deform it at one end from the 'D' shape into a substantially circular shape in cross section (56). The deforming process is performed by any one of a number of standard die processes. A more detailed view of the deformation of the rung is shown in the cut away sections depicted in Figure 6. The deforming process is repeated for the other end of the rung (not shown). The deformed rung provides a non-uniform cross section about which epoxy adhesive can set and retain the rung.

With reference to Figures 7A and 7B, a female stile (58) in the form of an elongate length of smooth timber is formed by cutting to the length required for a ladder (not shown). Preferred timbers include *Pinus radiata, Eucalyptus delegatensis* and *Eucalyptus regnans*. Cut-outs (60) are optionally removed at regular intervals along the length in order to lighten the member without significantly weakening it. The member is varnished (not shown) to improve weatherproofness of the wood and to improve the finish. A preferred varnish is a single-pack polyurethane varnish. Alternatively, the stile may be painted. A preferred paint is a high-gloss enamel. Annular grooves are trepanned into the member to form sockets (62).

With reference to Figure 8, a curing box (64) is provided to hold all the parts, rungs and stiles, in their correct relationship to each other while a binding material is allowed to set the joints of the ladder. The box has a sufficient length to accommodate the different lengths of stiles used to make ladders of different lengths. In width, it preferably accommodates multiple stiles, and hence ladders, stacked side by side. The box (64) has a substantially level setting table (68), perpendicular surrounding walls (70) and a removable lid (72). The walls (70), setting table (68), and lid (72) are thermally insulated. When the lid is fitted, the box becomes an enclosed vessel within which the ambient pressure and temperature may be controlled.

A set of fans (74 and 76) is provided to circulate air inside the box (64) in a swirling motion so as to thoroughly mix the air and ensure that the temperature remains even throughout the box (64). The box (64) is additionally fitted with a heater (78) and a sensitive programmable thermostat (80).

Ladders (complete ladder not shown) are built one stile at a time. A first stile (82), as described above with reference to Figures 7A and 7B, is laid on its outside face on the setting table and pushed into a corner defined by the intersection (not shown) of one of the longitudinal walls and the setting table (68).

With reference to Figure 10, the stile (96) described above with reference to Figures 7A and 7B, with annular groove sockets (62 of Figure 7), one of which is shown as (98), are placed uppermost and are each filled with a measured volume of binding material (100) in the form of premixed liquid resin and hardener. A tubular 'D' section rung (102) with a deformed end (103), as described above with reference to Figures 5 and 6, is now inserted completely in to the bottom (104) of the annular groove (98) such that the deformed portion thereof (103) and part of the undeformed portion thereof (106) are below the level of the binding material (100). The binding material (100) is displaced such that it now

completely fills the groove (98) to the top (108), but no more. The process with respect to the rung insertion is repeated for each rung to be inserted into the stile (96).

A jig stile (110) is now fitted over the uppermost ends (112) of all of the rungs (102) and the jig stile (110) is also pushed into the same corner as the lower stile (96) described above with reference to Figure 8.

With reference to Figure 10, the jig stile (114) has shouldered holes (116) which are not round holds but 'D' shaped in plan view and arranged so that they hold the top grip surface of the rungs (not shown) at an angle α of 75 degrees to the longitudinal axis of the stiles. The 'D' profile portion of the hole goes most of the way through the jig stile and the smaller portion of the hole (118) above the shoulder is round and extends all the way through the jig stile.

With reference to Figure 11, when the jig stile (120), described above with reference to Figure 7, is fitted and both it and the ladder stile (122) (described above with reference to Figure 7) are retained against a longitudinal side wall and against one end wall of the box (described above with reference to Figure 8), the whole assembly (124) comprising the jig stile (120), stile (122) and rungs (126) is held straight and square and free of twist and the rungs (126) are held in their correct relationship to each other and to the stiles (120 and 122).

Additional ladders may now be assembled in the same manner and likewise pushed up to the end of the box (described above with reference to Figure 8) and held against the edge of the previous ladder. Thus all ladders assembled into the box are held straight and square and free of twist.

With reference to Figure 9 again, after a period of time has elapsed (usually about 30 minutes), the binding material (100) will have soaked somewhat into the wood (101 and 103) surrounding the groove (98) and the top surface of the

binding material will thus be not be at the top of the groove (98). Although the binding material (100) will have begun to polymerise it will still be liquid at this stage in the process. At a chosen stage in the process a further small quantity of binding material (not shown) is pumped through all of the holes (105) in the top surface of the jig stile(s) (described above with reference to Figure 10). This binding material falls to the bottom of the grooves (104) and flows around the embedded ends of the rungs. This is because the binding material is still liquid and the rung ends (107) have apertures designed to facilitate the binding material flow. The further binding material refills the grooves (98) back to level with the top face of the bottom stile. At this stage in the process the binding material no longer soaks into the wood as it has set sufficiently to prevent this. The binding material level remains at the top of the groove (108).

Again with reference to Figure 9, the lid (72) is now placed on the box (64) and the box (64) is gently heated using the heater (78) in order to speed the setting of the binding material. The heating cycle is controlled by the thermostat (80). The cycle comprises heating gently because heating the binding material too fast causes bubbles to form in the binding material leading to a weaker assembly. The heating is increased more rapidly after the binding material has gelled in order to rapidly harden the binding material to the point that the ladder can be removed from the box (64) for the next process without deforming the stile (82) and rungs (84) and binding material (figure 4, 48) which now form an assembly (86).

When the binding material (figure 4, 48) has set sufficiently, the lid (72) is removed from the box (64) and the jig stiles (88) are removed from the tops of all of the rungs (84). The box (64) and contents are now allowed, or assisted by forced air circulation by the fans (74), to cool. A measured volume of premixed resin and hardener binding material is now poured into the open, upper, ends of all the rungs (90). This volume of resin poured into the upper end of each rung (90) is the same quantity or a slightly larger quantity of total binding material

introduced into the each groove described above with reference to Figure 9. A second stile (not shown) prepared as described above with reference to Figure 7, to complete the ladder, is now fitted over the upper ends of the rungs (90) such that the upper ends of the rungs (90) are inserted all the way to the base of all of the annular grooves of the second stile. This step is repeated for each of the stile/rungs assemblies in the box.

The completed ladders are now turned over so that the outside face of the second stile is placed on the setting table (68) of the box and the ladders are pushed up to one side and one end of the box, as described above. The ladders are thus held straight and square and free of twist and the rungs are held at the correct angle and parallel to each other.

The unset binding material now runs down to what is now the bottom of the rung (84) and partially fills the associated annular groove in the second stile. The binding material flow around the end of the rung to completely fill the groove is inhibited because of an air-lock which forms inside the rung. There are two methods which can be used to cause the binding material to flow to the correct level and a combination of both methods could also be used.

The first method which can be used to flow the binding material to the correct level so as to fill the groove to level with the top face of the stile is to gently heat the whole assembly using the heater (78). This heats air trapped inside each rung (84) and thus increases the pressure inside the rung. This increased pressure drives the binding material down the rung and through the apertures or holes in the rung to fill the groove outside the rung as well as inside the rung. To facilitate this method, the lid (72) is placed on the box (64) and the fans (74 and 76) are set in motion to drive the air around inside the box to create the mixing effect. The thermostat (80) is set at the required temperature and the heater (78) switched on. The process is controlled so as to very gently heat the inside of the box (64) evenly. The temperature is increased very slightly and very gradually so that the

excess binding material within the rung is displaced to fill the groove completely on the outside of the rung as well as still leaving it filled on the inside of the rung to at least the level of the top of the socket. This displacement also compensates for the soakage into the wood surrounding the annular groove, which will occur during the first part of the process of this first method.

As before the temperature is carefully monitored until the binding material has gelled and thereafter the temperature is increased to a higher temperature and more quickly so as to set the binding material hard without undue delay so that the ladders can be completed and the box used for another batch.

The second method which can be used to drive the binding material through the apertures or holes in the rungs to the correct level is to reduce the air pressure in the box (64) surrounding the rungs. The pressure differential thus drives the binding material to the correct level. To facilitate this process the lid (72) is placed on the box (64) and sealed so the box (64) is airtight. The pressure inside the box (64) is now reduced by a pump (92) and carefully controlled and monitored by a pressure gauge (94) so that the binding material fills the groove level with the top face of the lower stile. The pressure will be lowered very gradually during the first part of the process cycle so as to account for the soakage of the binding material into the wood.

Both of the above methods can be controlled by a PLC (programmable logic controller) circuit (not shown) appropriately programmed and connected to thermostats, barometers and level sensors.

A combination of the two methods outlined above can be used to provide a faster cycle time. If the box (64) is appropriately designed and made the temperature inside the box can be increased rather more that would be the case for the first method above and the excess pressure inside the rung (which would drive the binding material too far and overflow the groove) is compensated for by

increasing the pressure of the air inside the box. Thus a temperature cycle can be designed to take advantage of the best setting time for the binding material without bubbling it and the level of the binding material is controlled by the pressure regime while the whole process is run by the PLC in conjunction with the level sensor.

It will be appreciated by those persons skilled in the art that the foregoing description is provided by way of example only and that the scope of the invention is not limited thereto.

Claims

1. A structural support assembly comprising at least a male member in engagement with a settable binding material in engagement with a wooden female member, wherein:

   the male member has an open-ended hollow projection, the projection defining an inner wall and an outer wall;

   the female member has a socket defined therein by a groove in the form of a closed loop having opposing walls, the groove being shaped to receive said projection of the male member such that the projection of the male member forms a clearance fit with the socket of the female member;

   the binding material contacts opposing walls of the socket of the female member and the inner and outer walls of the projection of the male member; and

   said binding material has permeated and strengthened the wooden female member adjacent the socket.

2. A structural support assembly as claimed in claim 1 wherein the settable binding material, in its unset state, has a fraction with a viscosity of between 200 and 1000 centipoise.

3. A structural support assembly as claimed in claim 2 wherein the fraction comprises at least 5% by weight of the total binding material.

4. A structural support assembly as claimed in any one of the preceding claims wherein the binding material contacts a major proportion of the opposing walls of the socket of the female member.

5. A structural support assembly as claimed in claim 4 wherein the binding material contacts at least 80% of the opposing walls of the socket of the female member.

6. A structural assembly as claimed in any one of the preceding claims wherein the binding material contacts a major portion of the portion of the inner and outer walls of the projection of the male member within the confines of the socket.

7. A structural assembly as claimed in claim 6 wherein the binding material contacts at least 80% of the portion of the inner and outer walls of the projection of the male member within the confines of the socket.

8. A structural support assembly as claimed in any one of the preceding claims wherein at least one of the members is elongate.

9. A structural support assembly as claimed in claim 8 wherein both members are elongate.

10. A structural support assembly as claimed in claim any one of the preceding claims wherein the projection is an end of the male member.

11. A structural support assembly as claimed in any one of claims 1 to 9 wherein the projection protrudes from a portion along the length of the male member.

12. A structural support assembly as claimed in any one of the preceding claims wherein the socket is defined by an end of the female member.

13. A structural support assembly as claimed in any one of claims 1 to 11 wherein the socket is defined in a portion along the length of the female member.

14. A structural support assembly as claimed in any one of the preceding claims wherein the structural support assembly is incorporated into a construction selected from the group comprising a ladder, stepladder, scaffold and truss.

15. A structural support assembly as claimed in any one of the preceding claims wherein either member is a stile and the other member is a rung.

16. A structural support assembly as claimed in claim 15 wherein the male member is a rung and the female member is a stile.

17. A structural support assembly as claimed in any one of the preceding claims wherein the male member is a 'D' sectioned rung.

18. A structural support assembly as claimed in claim 17, wherein the flattened surface of the 'D' is at an angle of between 65 degrees and 90 degrees to the longitudinal axis of the stile.

19. A structural support assembly as claimed in claim 18, wherein the flattened surface of the 'D' is set at an angle of 75 degrees to the longitudinal axis of the stile.

20. A structural support assembly as claimed in any one of the preceding claims wherein the socket is an annular groove.

21. A structural support assembly as claimed in any one of the preceding claims wherein the projection of the male member is of a different shape from the female member in cross section such that it contacts both the inner and outer walls of the socket at different portions in cross section.

22. A structural support assembly as claimed in any one of the preceding claims wherein the male member has protrusions which contact at least one of the walls of the socket.

23. A structural support assembly as claimed in any one of the preceding claims wherein the projection on the male member is deformed so as to have an different profile in cross section along its length proximal an end thereof.

24. A structural support assembly as claimed in any one of the preceding claims wherein the projection of the male member has at least one hole which is filled with binding material.

25. A structural support assembly as claimed in any one of the preceding claims which further comprises a second structural support assembly as claimed in any one of the preceding claims, wherein one of the members of the first assembly is also a member of the second support assembly.

26. A structural support assembly as claimed in any one of the preceding claims wherein the members are weatherproof.

27. A structural support assembly as claimed in any one of the preceding claims wherein the binding material is a polymer.

28. A structural support assembly as claimed in claim 27 wherein the binding material is a resin selected from the group comprising epoxy, polyester, polyurethane, and acrylic.

29. A structural support assembly as claimed in claim 28 wherein the resin is a hot-melt resin selected from the group comprising isocyanate-based and polyurethane-based resins, and combinations thereof.

30. A structural support assembly as claimed in any one of claims 3 to 29 wherein the fraction component is at least 10%.

31. A structural support assembly as claimed in claim 30, wherein the fraction component is at least 20%.

32. A structural support assembly as claimed in any one of the preceding claims wherein the overall viscosity of the unset binding material is between 200 and 10 000 centipoise.

33. A structural support assembly as claimed in claim 32 wherein the overall viscosity of the binding material is between 2000 and 7000 centipoise.

34. A structural support assembly as claimed in claim 33 wherein the overall viscosity of the binding material is between 4000 and 6000 centipoise.

35. A process for manufacturing a structural support assembly comprising the steps of :

providing a wooden female member with a socket defined therein by a groove in the form of a closed loop having opposing walls;

providing a male member having an open-ended hollow projection which defines an inner wall and an outer wall such that it forms a clearance fit with the socket of the female member;

inserting the male member projection into the female member socket;

either before or after this insertion of the male member projection into the female member socket, introducing a binding material into at least the socket wherein the binding material is permitted to permeate the wooden female member adjacent the socket and contact at least the opposing walls of the socket and when the male member projection is inserted into the female member socket, the inner and outer walls of the projection of the male member;

retaining the male member in a predetermined relationship with the female member; and

hardening the binding material.

36. A process according to claim 35 wherein the settable binding material, in its unset state, has a fraction with a viscosity of between 200 and 1000 centipoise.

37. A process according to claim 35 or claim 36 wherein the fraction comprises at least 5% by weight of the total binding material.

38. A process according to claim 37 wherein the fraction component is at least 10%.

39. A process according to claim 38, wherein the fraction component is at least 20%

40. A process according to any one of claims 35 to 39 wherein the overall viscosity of the unset binding material is between 200 and 10 000 centipoise.

41. A process according to claim 40 wherein the overall viscosity of the binding material is between 2000 and 7000 centipoise.

42. A process according to claim 41 wherein the overall viscosity of the binding material is between 4000 and 6000 centipoise.

43. A process according to any one of claims 35 to 42 wherein the process additionally comprises the step of forming the projection on the male member.

44. A process according to any one of claims 35 to 43 wherein the binding material is a resin selected from the group comprising epoxy, polyester, polyurethane, and acrylic.

45. A process according to any one of claims 35 to 44 wherein the binding material is applied to the projection, the socket or both the projection and the socket.

46. A process according to any one of claims 35 to 45 wherein the process additionally comprises retaining the members in a jig in a predetermined relationship with one another until the binding material has hardened.

47. A process according to any one of claims 35 to 46 wherein the process additionally comprises forming at least one hole in the male member projection.

48. A process according to any one of claims 35 to 47 wherein the process for producing the female member with a groove comprises the steps of:
manufacturing the female member;
finishing the female member with a varnish or a paint;
forming the socket in the female member by trepanning an annular groove into the female member.

49. A process according to any one of claims 35 to 48 wherein the step of inserting the male member projection into the female member socket comprises:

50. placing the female member on a substantially horizontal surface with the socket facing upwardly;
placing the projection of the male member in the socket; and
optionally orientating the male member with respect to the female member.

51. A process according to any one of claims 35 to 49 wherein the process of retaining the projection in the socket in a predetermined relationship is achieved by retaining at least the male member in a jig.

52. A process according to any one of claim 49 or claim 51 wherein the male member is tubular.

53. A process according to claim 52 wherein the process of introducing the binding material into at least the socket is achieved by introducing the unset binding material into an open top end of the male member and permitting the binding material to settle in the socket.

54. A process according to any one of claims 35 to 53 wherein the temperature is controlled during setting of the binding material.

55. A process according to any one of claims 35 to 54 wherein the ambient pressure is controlled during setting of the binding material.

56. A process according to any one of claims 52 to 55 wherein a pressure differential gradient is established between the inside of the tubular member and the ambient pressure.

57. A process according to claim 56 wherein the pressure differential gradient is about 0.25 psi (about 1700 Pa).

58. A structural support assembly produced by a process according to any one of claims 35 to 57.

59. A ladder containing at least one joint according to any one of claims 1 to 34.

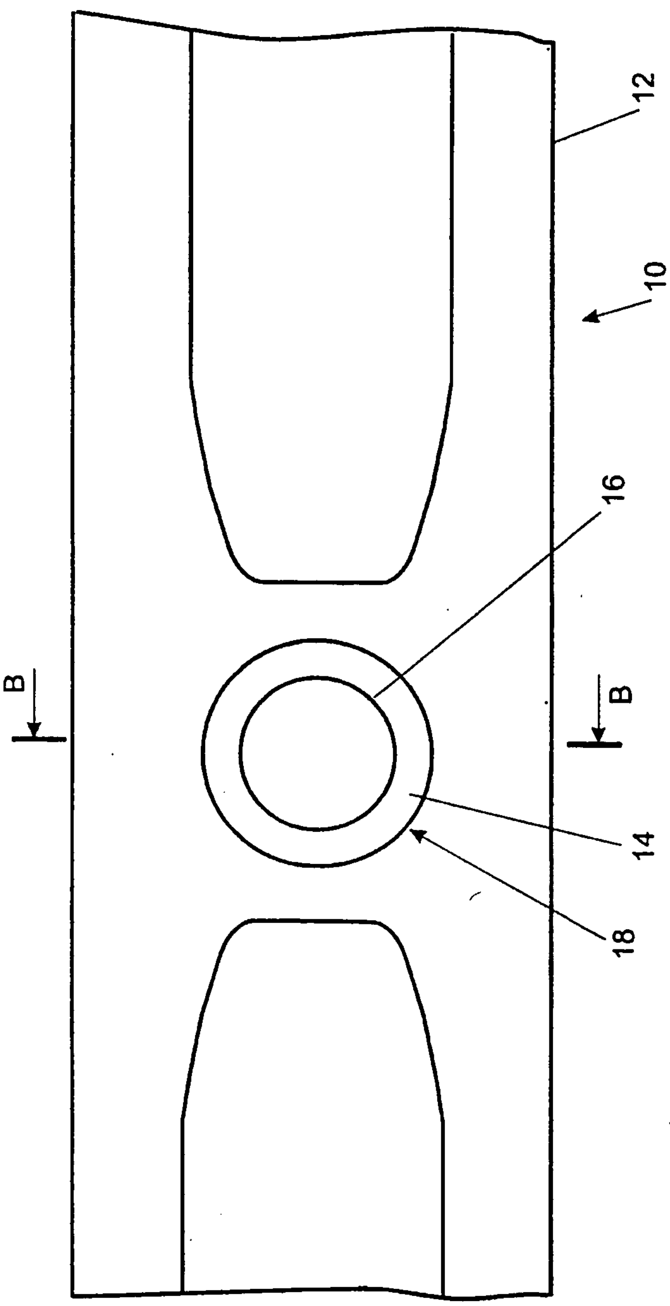

FIGURE 1A

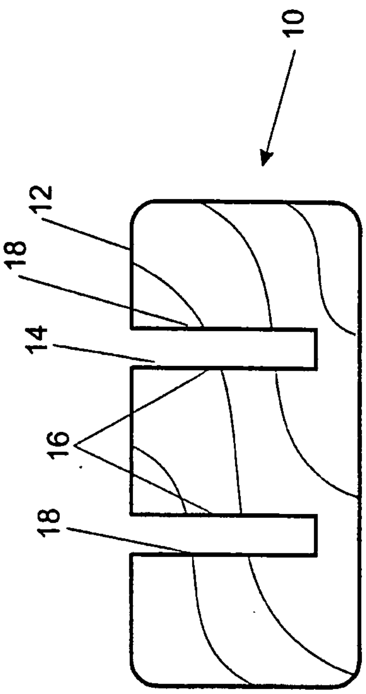

FIGURE 1B

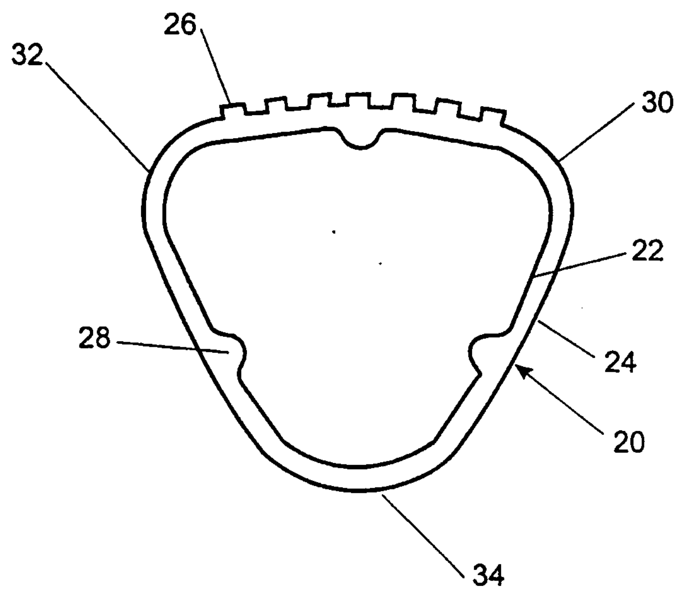

FIGURE 2

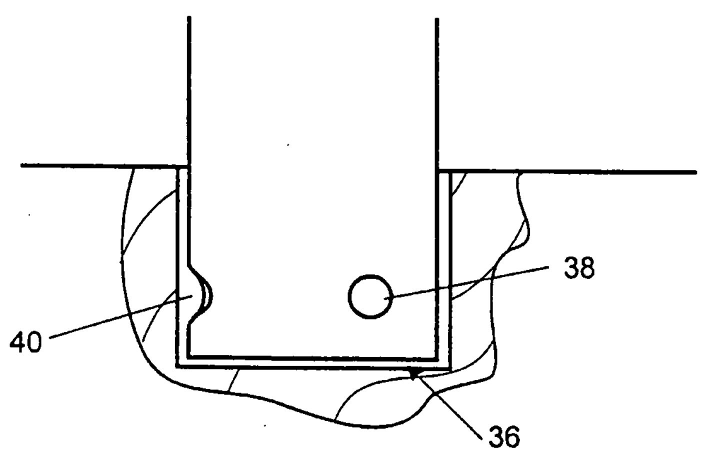

FIGURE 3

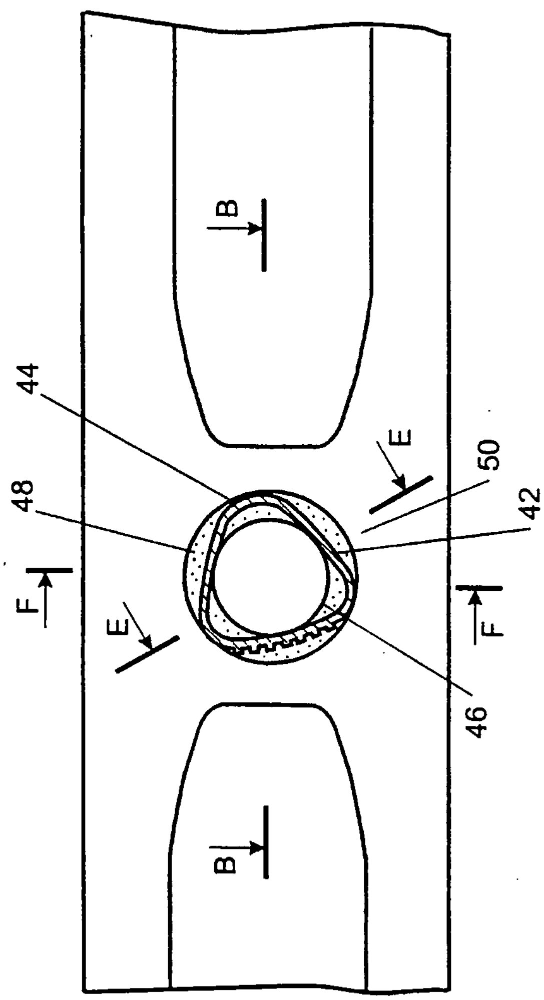

FIGURE 4A

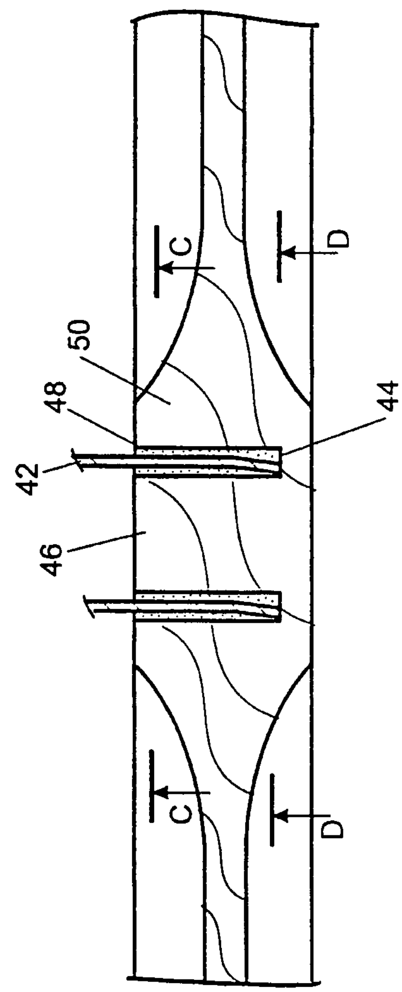

FIGURE 4B

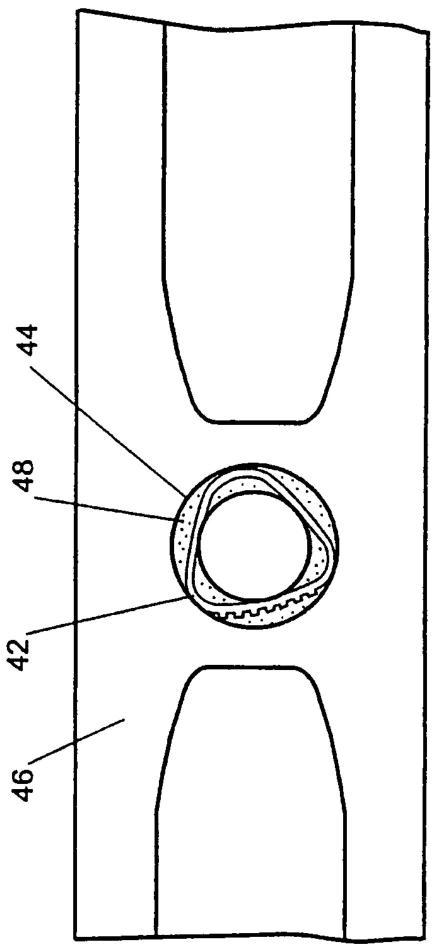

FIGURE 4C

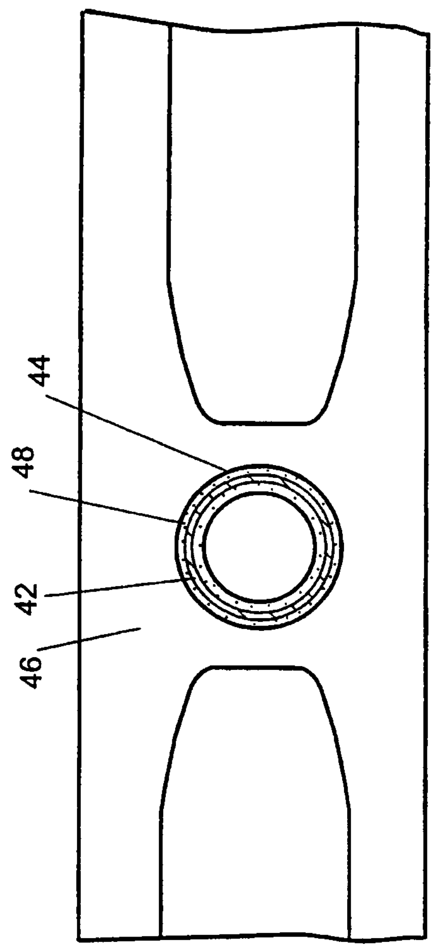

FIGURE 4D

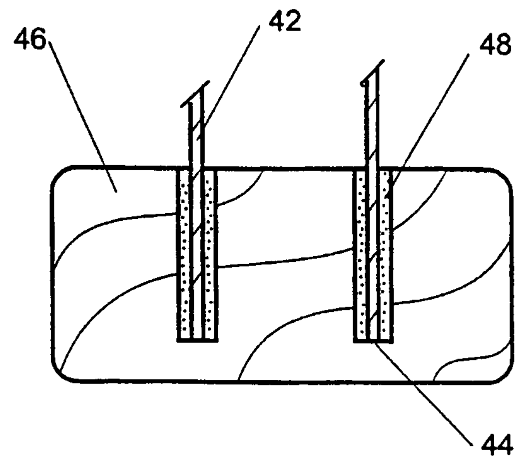

FIGURE 4E

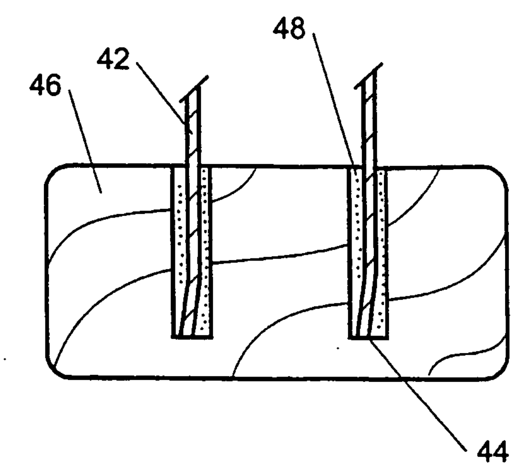

FIGURE 4F

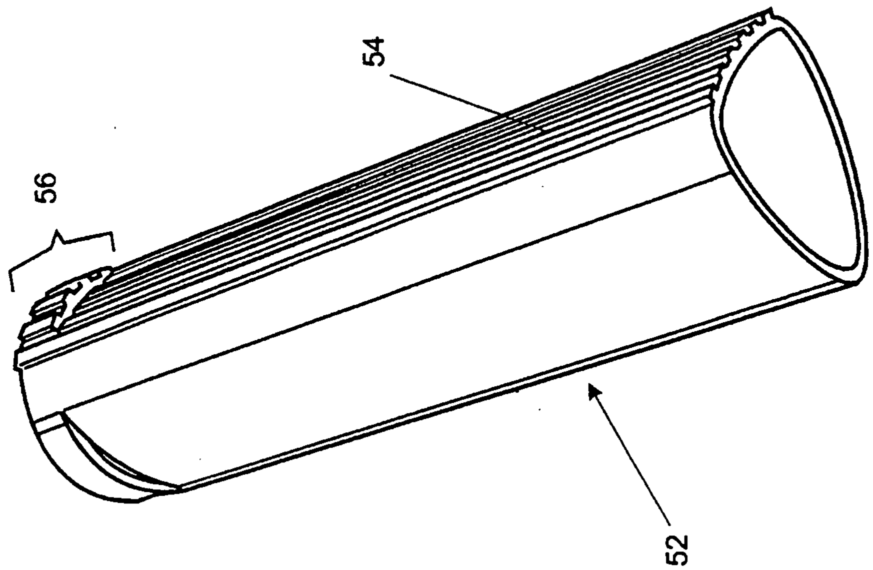

FIGURE 5B

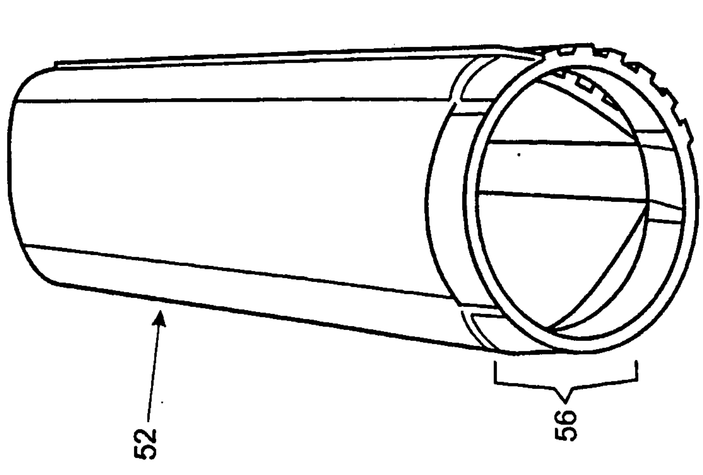

FIGURE 5A

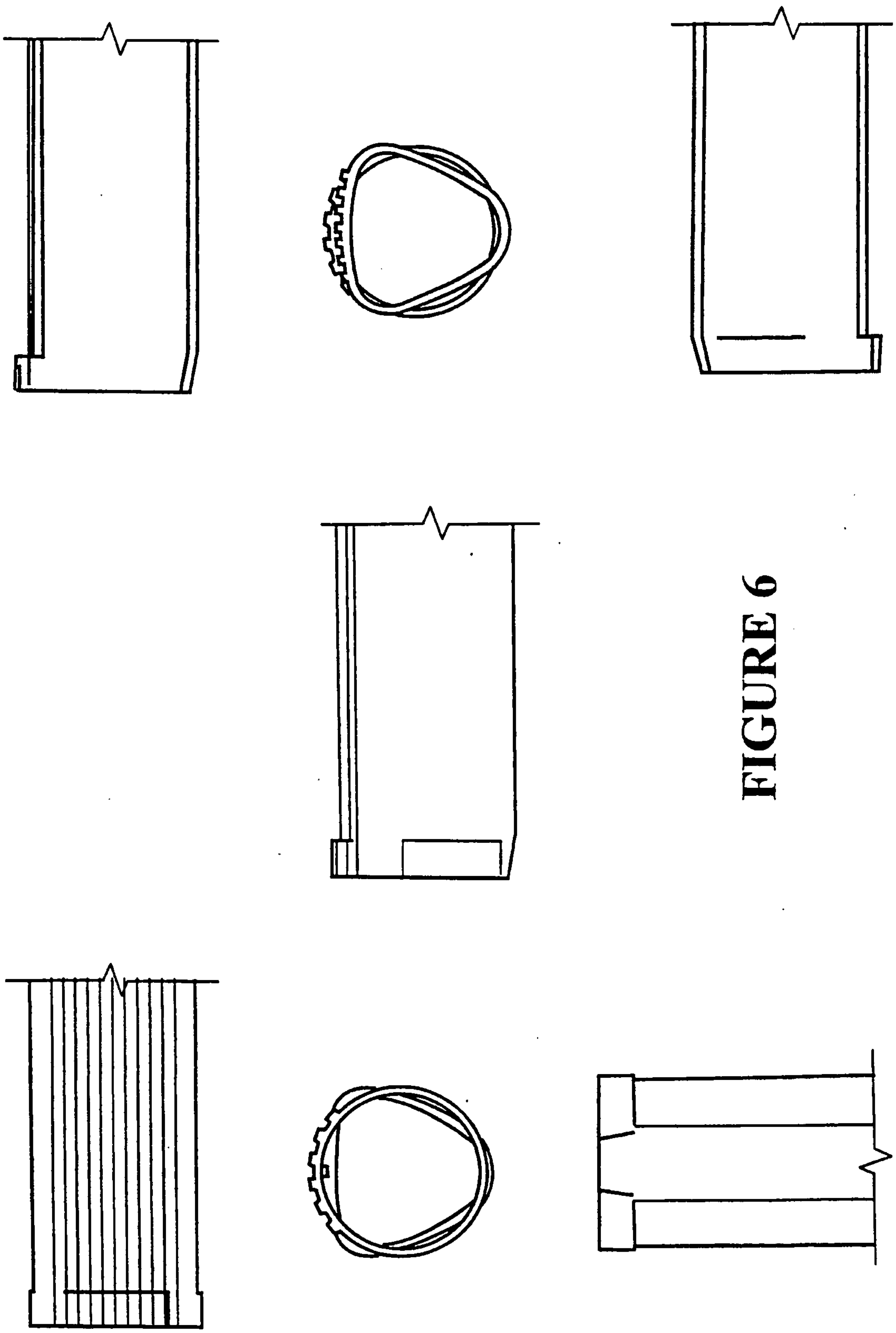

FIGURE 6

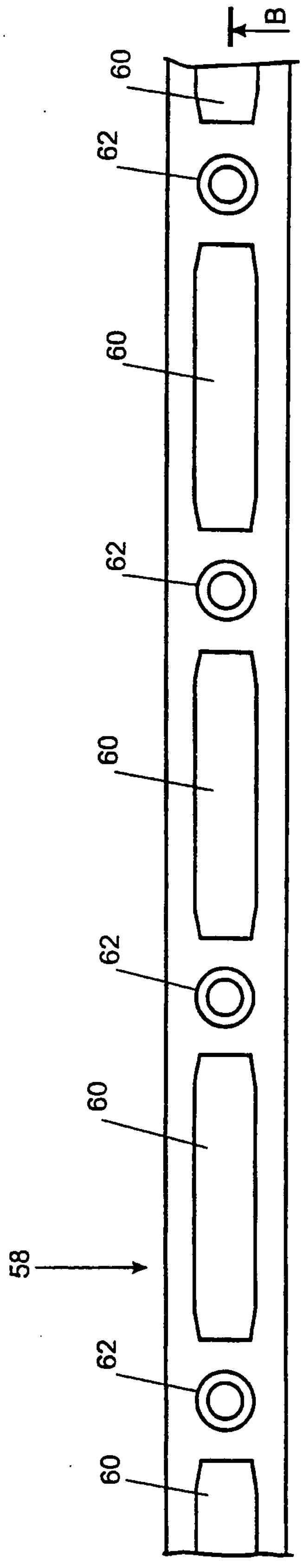

FIGURE 7A

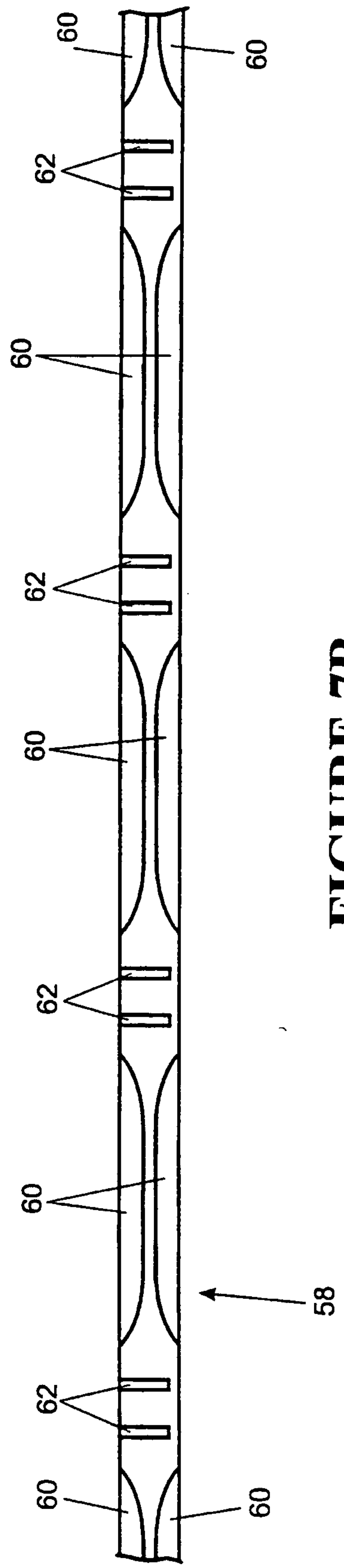

FIGURE 7B

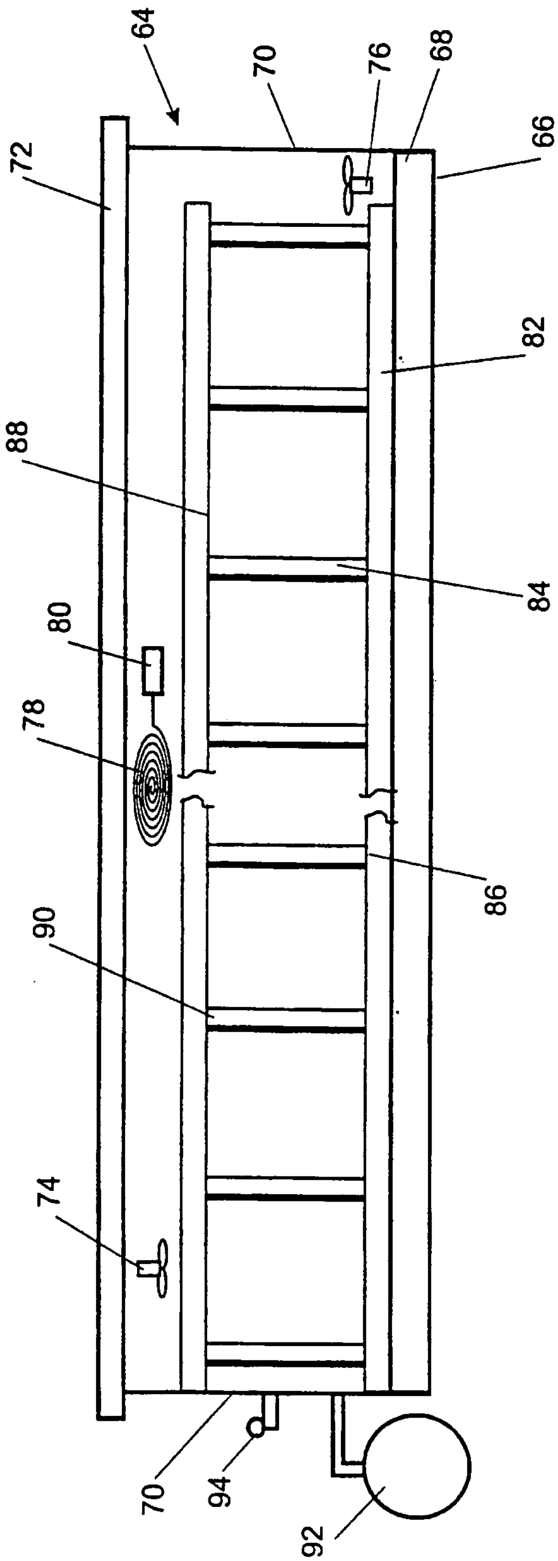

FIGURE 8

SUBSTITUTE SHEET (Rule 26)

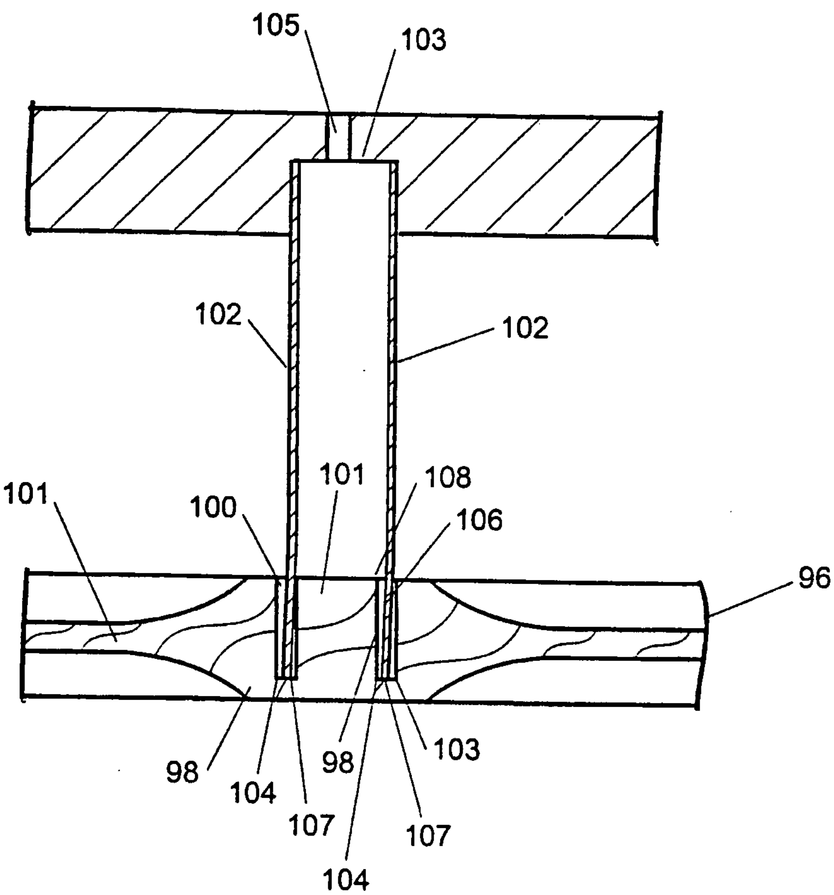

FIGURE 9

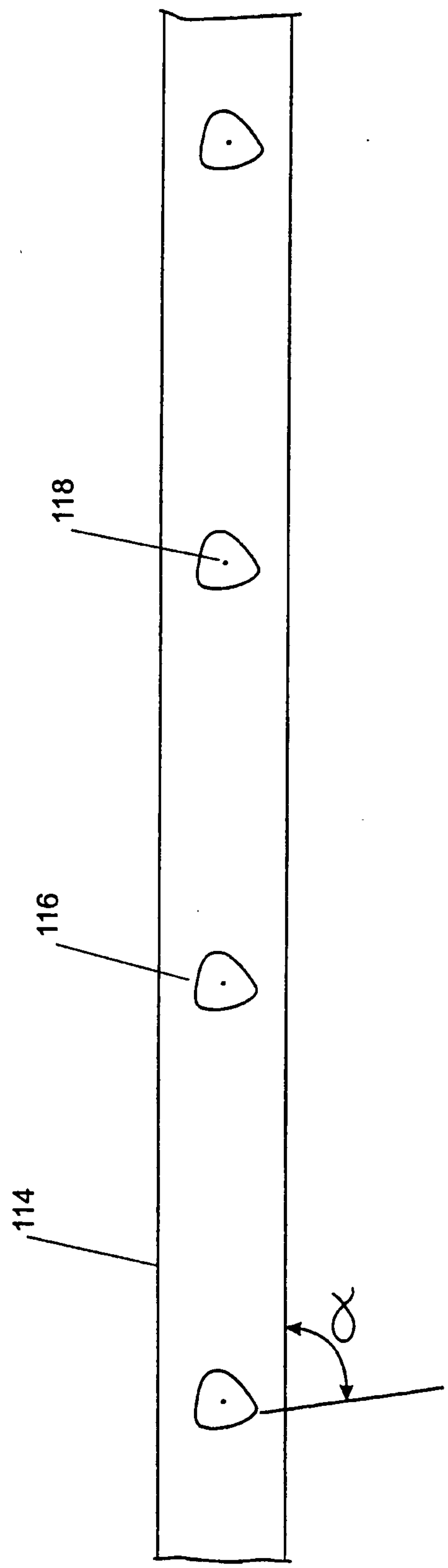

FIGURE 10

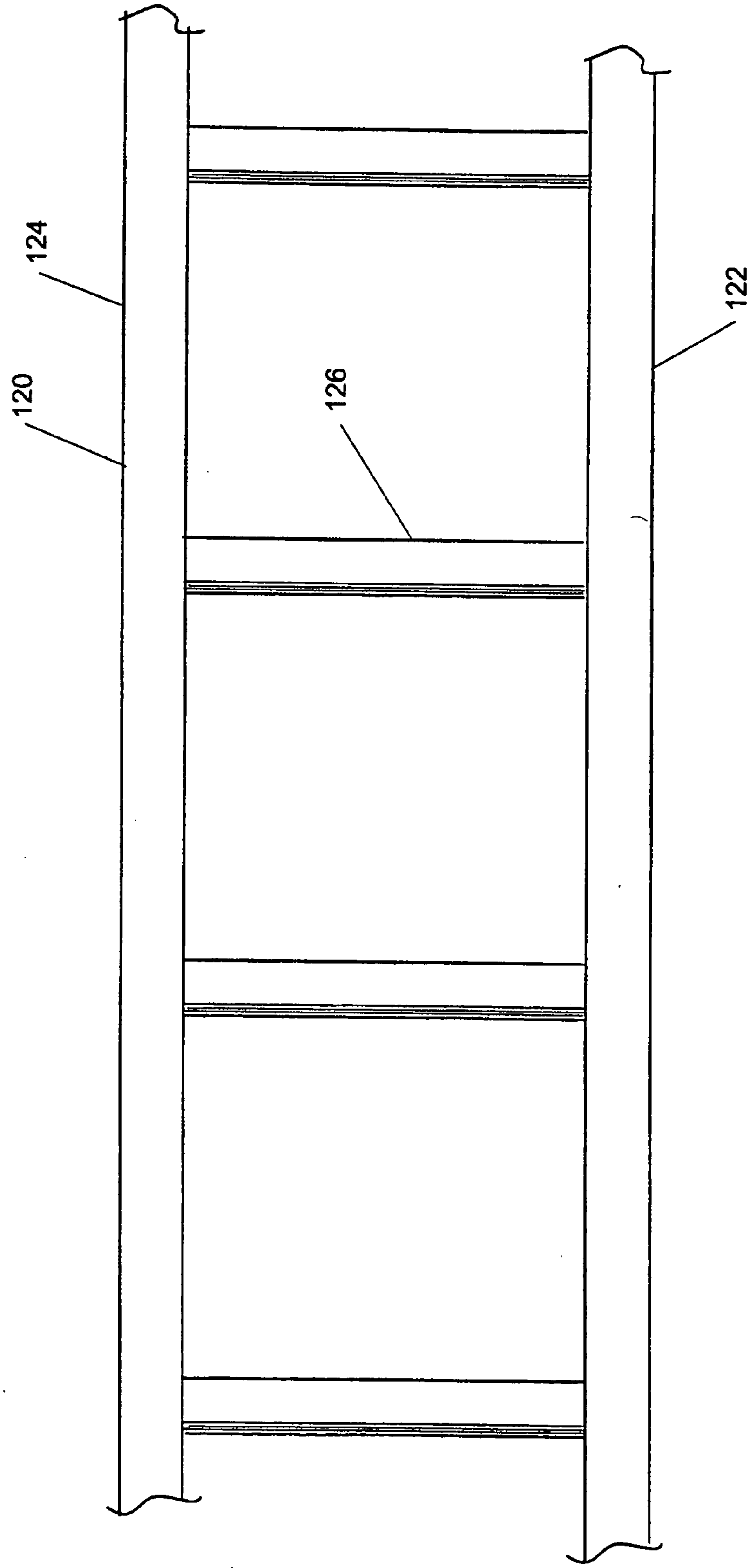

FIGURE 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ00/00028

A.	**CLASSIFICATION OF SUBJECT MATTER**
Int. Cl. [7]:	E04B 1/38, 1/48, E06C 7/50, F16B 12/24, 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: Int. Cl. as above

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT: keywords

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2706802 A1 (ESABLISSEMENTS ROBERT WEISROCK SA) 30 December 1994 See the Derwent Abstract	1, 4-8, 10, 11-13, 20, 24, 27-29, 35, 43-57
X	CH 233812 (KOBERLE) 16 November 1944 See the figures	1, 35
A	EP 572955 A1 (HOME CO., LTD.) 8 December 1993	

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 June 2000	29 JUN 2000
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer VINCE BAGUSAUSKAS Telephone No : (02) 6283 2110

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NZ00/00028

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member					
EP 572955	AU 671633	AU 679411	AU 679412	CA 2097119	EP 572955	JP 5331919
	US 5466086	US 5788396	US 5788397	US 5807014	US 5807015	US 5873672
	US 5906451	US 5924815				

END OF ANNEX